PART I

INITIATION OF CLIMATE CHANGE PROGRAMS

The following three chapters address issues that policy-makers should consider and understand at the outset of climate change program development. These chapters advocate formulation of a strong and deliberate program focus. They are intended to help states gather information, envision the climate change policy context, and anticipate and prepare for critical issues that are likely to arise during program development.

- Chapter 2, *Background on Climate Change Science and Policy*, presents background information on climate change science, international, national and state responses to climate change, and a general framework for policy analysis and program development.

- Chapter 3, *Measuring and Forecasting Greenhouse Gas Emissions,* highlights how states can measure greenhouse gas emissions and anticipate the probable impact of various policy options.

- Chapter 4, *Establishing Emission Reduction Program Goals and Evaluative Criteria*, discusses the importance of setting clear and feasible program goals, and offers examples of specific policy evaluation criteria that states can use.

This information sets the context for Part II, which discusses specific technical approaches and policy options for reducing greenhouse gas emissions, and Part III, which elaborates on organizational, political, and analytic complexities surrounding climate change policy selection and program development.

CHAPTER 2
BACKGROUND ON CLIMATE CHANGE SCIENCE AND POLICY

Initiating climate change response programs requires a basic understanding of the underlying scientific, technical, organizational, and political issues. The purpose of this chapter is to familiarize policy-makers with the current scientific understanding of global climate change and to set the broader policy context for greenhouse gas reduction measures. The first section of this chapter introduces the greenhouse effect and the changes in climate expected to result from increasing atmospheric concentrations of greenhouse gases. The second section describes international and national responses to climate change and identifies the role of states in mitigating this threat. The third section presents a framework for climate change policy analysis that provides the structure for the remainder of this document and the basis for climate change program development. The final section uses an example of comprehensive policy planning to illustrate many of the points made throughout this chapter.

2.1 INTRODUCTION TO CLIMATE CHANGE

The Earth's climate is the result of a complex system driven by many factors, including radiant energy from the sun, volcanic activity, and other natural phenomena. Human activities, specifically those that result in emissions of greenhouse gases, may affect this complex system and alter the Earth's climate. While the atmosphere's natural greenhouse effect is relatively well understood, uncertainties surrounding the effects of increased concentrations of greenhouse gases still exist. This section describes the scientific and technical aspects of climate change and the impacts which may result at both global and regional levels.

2.1.1 Scientific and Technical Aspects of Global Climate Change

The climate of the Earth is affected by changes in radiative forcing attributable to several sources including the concentrations of radiatively active (greenhouse) gases, solar radiation, aerosols, and albedo.[1] Greenhouse gases in the atmosphere are virtually transparent to sunlight (shortwave radiation), allowing it to pass through the air and to heat the Earth's surface. The Earth's surface absorbs the sunlight and emits thermal radiation (longwave radiation) back to the atmosphere. Because some gases, such as carbon dioxide (CO_2), are not transparent to the outgoing thermal radiation, some of the radiation is absorbed, and heats the atmosphere. In turn, the atmosphere emits thermal radiation both outward into space and downward to the Earth, further warming the surface. This process enables the Earth to maintain enough warmth to support life: without this natural "greenhouse effect," the Earth would be approximately 55^{o} F colder than it is today. However, increasing concentrations of these greenhouse gases are projected to result in increased average temperatures, with the potential to warm the planet to a level that could disrupt the activities of today's natural systems and human societies.

Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3).[2] Some human-made compounds — including chlorofluorocarbons (CFCs),

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[1] Albedo is the fraction of light or radiation that is reflected by a surface or a body. For example, polar ice and cloud cover increase the Earth's albedo. "Radiative forcing" refers to changes in the radiative balance of the Earth, *i.e.*, a change in the existing balance between incoming and outgoing radiation. This balance can be upset by natural causes, *e.g.*, volcanic eruptions, as well as by anthropogenic activities, *e.g.*, greenhouse gas emissions.

[2] Ozone exists in the stratosphere and troposphere. In the stratosphere (which starts about 8.4 miles above the Earth's surface), ozone provides a protective layer shielding the Earth from ultraviolet radiation and subsequent harmful health effects on humans and the environment. In the

partially halogenated fluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorinated carbons (PFCs) — are also greenhouse gases. In addition, there are photochemically important gases such as oxides of nitrogen (NO_x) and nonmethane volatile organic compounds (NMVOCs) that, although not greenhouse gases, contribute indirectly to the greenhouse effect by influencing the rate at which ozone and other greenhouse gases are created and destroyed in the atmosphere.

Greenhouse gases are emitted by virtually all economic sectors, including residential and commercial energy use, industrial processes, electricity generation, agriculture, and forestry. Exhibit 2-1 contains a brief description of these gases, their sources, and their roles in the atmosphere.[3] Exhibit 2-2 discusses how the potential warming effects of these gases are usually expressed using a common scale, viz., global warming potential. Figure 2-1 presents a summary of U.S. greenhouse gas emissions, by gas, weighted by global warming potential. Later in this document, Chapter 3 provides a complete list of emission sources and Chapter 5 elaborates on the emission characteristics and options for addressing emissions from each source.

2.1.2 Potential Impacts of Global Climate Change

Although CO_2, CH_4, and N_2O occur naturally in the atmosphere, rising levels of these gases in the atmosphere are attributed mainly to anthropogenic activities. This buildup has altered the composition of the earth's atmosphere, and possibly will affect the future global climate. Since about 1750, atmospheric concentrations of carbon dioxide have increased by about 30 percent, methane concentrations haveincreased by 145 percent, and nitrous oxide concentrations have risen approximately 15 percent (IPCC, 1996). And, from the 1950s until the mid-1980s, when international concern over CFCs grew, the use of these gases increased nearly 10 percent per year. The consumption of CFCs is declining quickly, however, as these gases are phased out under the *Montreal Protocol on Substances that Deplete the Ozone Layer*.[4] Use of CFC substitutes, in contrast, is expected to grow significantly.

Estimating the potential impact of increasing greenhouse gas concentrations on global climate has been a focus of research within the atmospheric science community for more than a decade. While there is considerable agreement within the scientific community that "climate has changed over the past century," and that "the balance of evidence suggests a discernible human influence on global climate," (IPCC, 1996), there is much less agreement about the timing, magnitude, or regional distribution of any climatic change. Uncertainties about the climatic roles of oceans and clouds as well as the feedback effects of oceans, clouds, vegetation, and other factors make it difficult to predict with certainty the amount of warming that rising levels of greenhouse gases will cause. Current evidence from climate model studies, however, suggests that by 2100, global average surface temperature will increase by 1.8

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troposphere (from the Earth's surface to about 8.4 miles above), ozone is a chemical oxidant and major component of photochemical smog. Most ozone is found in the stratosphere, with some transport occurring to the troposphere through the tropopause (the transition zone separating the stratosphere and the troposphere) (IPCC, 1992).

[3] For convenience, all gases discussed in this document are generically referred to as "greenhouse gases," although the reader should keep in mind the distinction between actual greenhouse gases and photochemically important trace gases.

[4] Recognizing the harmful effects of chlorofluorocarbons (CFCs), halons, and other compounds on the stratospheric ozone layer, many governments signed the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. This agreement limits the production and consumption of a number of these damaging compounds. As of June 1997, more than 160 nations are Parties to the Montreal Protocol. The US expanded its commitment to phase out these substances by signing and ratifying the Copenhagen Amendments to the Montreal Protocol in 1992. Under these amendments, the US committed to eliminating the production of all halons by January 1, 1994, all CFCs by January 1, 1996, and all HCFCs by January 1, 2030.

Exhibit 2-1. Greenhouse Gases and Photochemically Important Gases

The Greenhouse Gases

Carbon Dioxide (CO_2). The combustion of liquid, solid, and gaseous fossil fuels is the major anthropogenic source of carbon dioxide emissions. Some other non-energy production processes (*e.g.*, cement production) also emit notable quantities of carbon dioxide. CO_2 emissions are also produced by forest clearing and biomass burning. Atmospheric concentrations of carbon dioxide have been increasing at a rate of approximately 0.5 percent per year (IPCC, 1996).

In nature, carbon dioxide cycles between various atmospheric, oceanic, land biotic, and marine biotic reservoirs. The largest fluxes occur between the atmosphere and terrestrial biota, and between the atmosphere and surface water of the oceans. While there is a small net addition of CO_2 to the atmosphere from equatorial regions, oceanic and terrestrial biota in the Northern Hemisphere, and to a lesser extent in the Southern Hemisphere, act as a net sink of CO_2 (*i.e.*, remove more CO_2 from the atmosphere than they release) (IPCC, 1996).

Methane (CH_4). Methane is produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes, such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes, emit methane, as does the decomposition of municipal solid wastes. Methane is also emitted during the production and distribution of natural gas and oil, and is released as a by-product of coal production and incomplete fuel combustion. The atmospheric concentration of methane is increasing, although the rate of increase in the 1990s is lower than the rate observed in the 1970s and 1980s (IPCC 1996).

The major sink for methane is its interaction with the hydroxyl radical (OH) in the troposphere. This interaction results in the chemical destruction of the methane compound, as the hydrogen molecules in methane combine with the oxygen in OH to form water vapor (H_2O) and CH_3. After a number of other chemical interactions, the remaining CH_3 turns into CO which itself reacts with OH to produce carbon dioxide (CO_2) and hydrogen (H).

Halogenated Fluorocarbons, HFCs, and PFCs. Halogenated fluorocarbons are human-made compounds that include: chlorofluorocarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds not only enhance the greenhouse effect, but also contribute to stratospheric ozone depletion. Under the *Montreal Protocol* and the *Copenhagen Amendments*, which controls the production and consumption of these chemicals, the U.S. phased out the production and use of all halons by January 1, 1994 and phased out CFCs, HCFCs, and other ozone-depleting substances (ODSs) by January 1, 1996. Perfluorinated carbons (PFCs) and hydrofluorocarbons (HFCs), a family of CFC and HCFC replacements not covered under the *Montreal Protocol*, are also powerful greenhouse gases.

Nitrous Oxide (N_2O). Anthropogenic sources of N_2O emissions include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, adipic and nitric acid production, and biomass burning.

Ozone (O_3). Normal processes in the atmosphere both produce and destroy ozone. Approximately 90 percent of atmospheric ozone resides in the stratosphere, where it regulates the absorption of solar ultraviolet radiation; the remaining 10 percent is found in the troposphere and could play a significant greenhouse role. While ozone is not emitted directly by human activity, anthropogenic emissions of several gases influence its concentration in the stratosphere and troposphere. For example, chlorine and bromine-containing chemicals, such as CFCs, deplete stratospheric ozone.

Emissions of carbon monoxide, nonmethane volatile organic compounds, and oxides of nitrogen contribute to the increased production of tropospheric ozone (otherwise known as urban smog). Emissions of these gases, known as criteria pollutants, are regulated under the *Clean Air Act of 1970* and subsequent amendments.

Photochemically Important Gases

Carbon Monoxide (CO). Carbon monoxide is created when carbon-containing fuels are burned incompletely. Carbon monoxide elevates concentrations of methane and tropospheric ozone through chemical reactions with atmospheric constituents (*e.g.*, the hydroxyl radical) that would otherwise assist in destroying methane and ozone. It eventually oxidizes to CO_2.

Oxides of Nitrogen (NO_x). Oxides of nitrogen — NO and NO_2 — are created from lightning, biomass burning (both natural and anthropogenic fires), fossil fuel combustion, and in the stratosphere from nitrous oxide. They play an important role in climate change processes because they contribute to the formation of tropospheric ozone.

Nonmethane Volatile Organic Compounds (NMVOCs). Nonmethane VOCs include compounds such as propane, butane, and ethane. Volatile organic compounds participate along with nitrogen oxides in the formation of ground-level ozone and other photochemical oxidants. VOCs are emitted primarily from transportation, industrial processes, forest wildfires, and non-industrial consumption of organic solvents. (U.S. EPA, 1991).

Source: U.S. EPA, 1994.

Exhibit 2-2: Global Warming Potential (GWP)

The potential contribution to radiative forcing of the various greenhouse gases differ dramatically. Accurately calculating the amount of radiative forcing attributable to given levels of emissions of these gases, over some future time horizon, requires a complex and time-consuming task of calculating and integrating changes in atmospheric composition over the period. For policy purposes, the need is for an index that translates the level of emissions of various gases into a common metric in order to compare the climate forcing effects without directly calculating the changes in atmospheric concentrations (Lashof and Tirpak, 1990). This information can be used to calculate the cost-effectiveness of alternative reductions, *e.g.*, to compare reductions in CO_2 emissions with reductions in CH_4 emissions.

A number of approaches, called Global Warming Potential (GWP) indices, have been developed in recent years. These indices account for the direct effects of carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorinated carbons (PFCs). They also estimate indirect effects on radiative forcing due to emissions of gases which are not themselves greenhouse gases, but lead to chemical reactions that create or alter greenhouse gases.

The concept of global warming potential, which was developed by the Intergovernmental Panel on Climate Change (IPCC), compares the radiative forcing effect of the concurrent emission into the atmosphere of an equal quantity of CO_2 and another greenhouse gas. Each gas has a different instantaneous radiative forcing effect. In addition, emissions of different gases decay at different rates over time, which affects the atmospheric concentration. In general, CO_2 has a much weaker instantaneous radiative effect than other greenhouse gases; it decays more slowly, however, and hence has a longer atmospheric lifetime than most other greenhouse gases. While there is relative agreement on how to account for these direct effects of greenhouse gas emissions, accounting for indirect effects is more problematic

GWPs are used to convert all greenhouse gases to a CO_2-equivalent basis so that the relative magnitudes of different quantities of different greenhouse gases can be readily compared. The GWP potential will be an important concept for states in determining the relative importance of each of the major emissions sources and in developing appropriate mitigation strategies. A more detailed discussion on the development of GWPs can be found in the Phase I document, *States Workbook: Methodologies for Estimating Greenhouse Gas Emissions.*

to 6.3 ^{o} F, with a best estimate of 3.6^o F (IPCC, 1996). Global warming of just a few degrees would represent an enormous change in climate. For example, at the height of the last ice age, when glaciers covered the Great Lakes and reached as far south as New York, the global average temperature was only 5 to 9^o F colder than today (Hodges-Copple, 1990).

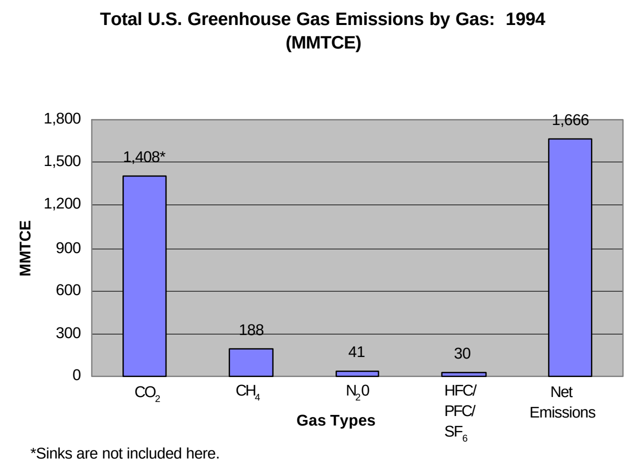
The impact of global climate change in various geographic areas and on various sectors of the world economy could be significant. Coastal areas are especially vulnerable. A recent EPA study (Titus and Narayanan 1995) projects that, in response to climate change, global *sea level* is most likely to rise 15 centimeters by the year 2050 and 34 centimeters by the year 2100. As global sea level rises, coastal areas in the US (particularly wetlands and lowlands along the Gulf and Atlantic coasts) are being inundated. Adverse impacts in these areas include loss of dryland and associated structures, loss of wetland and wildlife habitat, accelerated coastal erosion, exacerbated flooding, and increased salinity of rivers, bays, and aquifers (USEPA 1997).

Higher sea levels could also contaminate fresh water aquifers, which would increase the costs of fresh water supply either through deeper well drilling or importation of water from inland supplies. Sea level rise could also raise water tables in low lying coastal areas, which would increase flood damage, impede drainage, and reduce the effectiveness of sewage disposal facilities (Lesser et al., 1989). This impact could also place additional stress on infrastructure such as roads and bridges.

[5] Storm surges refer to the flooding induced by wind stresses and the barometric pressure reduction associated with major storms.

Climate change could have other impacts on *water resources*, as well. Changing climate is expected to increase both evaporation and precipitation in most areas of the United States (USEPA 1997). In those areas where the increase in evaporation is greater, there will generally be a decline in the availability of fresh water; where the increase in rainfall is greater, water may become more available. Climate models also suggest that seasonal changes are likely, with generally wetter winters and drier summers. Both climate models and empirical evidence suggest an increase in the frequency of intense rainstorms. The direct effects of a decline in water availability include declines in river flows, lake levels, and groundwater availability. The resulting impacts on society could include insufficient water for navigation; lower production of hydroelectric power; impaired recreational opportunities along rivers and lakes; poorer water quality; and decreased availability of water for agriculture, residential, and industrial uses. At the same time, warmer temperatures are likely to reduce soil moisture, which would increase the need for irrigation water. Increased water availability would generally have the opposite effects (USEPA 1997).

Figure 2-1
U.S. Greenhouse Gas Emissions and Sinks: 1994



Source: U.S. EPA, 1995
Note: MMTCE stands for million metric tons of carbon equivalent.

Climate change may also affect ecosystems, with impacts on commercial forestry, agriculture, and recreational and other uses of natural systems. *Forests* are likely to be affected in terms of their geographic distribution, species composition, and growth. Some areas that currently support forests may no longer be able to do so, while other areas that are not now forested could potentially support forests in the future. As with other predictions of climate change effects, there is considerable uncertainty in the impact estimates for forests, and results vary depending on assumptions made regarding forest type, region, climate projections, water availability, and the effect of higher carbon dioxide concentrations (USEPA 1997). Estimates also differ depending upon whether they address the transient period during which forests adjust to a change in climate or an equilibrium period after adjustments are completed. During a transient phase of adjustment to climate change, forests (particularly softwood forests in the southeast US) may suffer diminished productivity and dieback. The transformation of forests is a slow process during which current trees and other vegetation die and are succeeded by new vegetation, species migrate to sites with newly suitable climates, and soils develop. This transient or adjustment phase is expected to last decades to centuries after the climate ceases to change and has reached a new steady state. After forests are fully transformed and in equilibrium with a new and stable climate, forests in many areas of the US may be more productive than current forests and may expand in area (USEPA 1997).

Agriculture, always sensitive to climatic changes, is expected to be affected by global climate changes. Yields of many crops are likely to be affected by changes in average temperatures and precipitation as well as by changes in climate variability and the frequency of droughts and floods (USEPA 1997). Climate change may also affect availability of irrigation water, the prevalence of pests, and soil erosion. Increased CO_2 levels may increase yields (the "CO_2 fertilization effect"). Most projected impacts in the agriculture sector involve considerable uncertainty; different assumptions generate very different results that range from net benefits to net losses for US agriculture.

Existing studies suggest that the impacts on US agriculture will be modest in aggregate. Studies indicate that a doubling of CO_2 would change US agricultural production by a few percent. Total economic welfare changes are estimated to be within a range of plus or minus two percent. Projected nationwide impacts range from annual benefits of $10 billion to annual losses of $18 billion (USEPA 1997). Regional consequences could be greater in relative terms; there will be winners and losers. Climate change will increase production and economic welfare in some locations and decrease it in others. Under some scenarios, some regions could see losses of more than 10 percent while other see gains of more than 25 percent. When aggregated across regions, the gains and losses offset each other to produce a relatively small net impact.

One of the key regional-scale predictions is that production of some crops may migrate. As climate changes, some crops may expand into new regions and decline or disappear in some parts of their current range. The southern agricultural regions may be more vulnerable to adverse impacts.

Finally, regardless of a state's landscape or geological features, increased summer temperatures are expected to affect *human health*. In a warmer world, the frequency and intensity of extremely hot days are expected to increase, and would likely result in significant increases in annual weather-related mortality in US cities (USEPA 1997). Increased warmth and moisture may enhance the transmission of diseases by mosquitoes, ticks, and other insects. Climatic impacts on marine ecosystems may lead to increases in toxic algae species, contaminated seafood, and cases of seafood poisoning. Furthermore, increases in the persistence and level of air pollution episodes associated with climate change may have adverse health effects (Smith & Tirpak, 1989).

While scientists cannot predict the magnitude of climate effects from greenhouse gas emissions with absolute precision, the decision to limit emissions cannot wait until the full impacts are evident. Because greenhouse gases, once emitted, remain in the atmosphere for decades to centuries, stabilizing emissions at current levels would still allow the greenhouse effect to intensify for more than a century (Lashof and Tirpak, 1990). Thus, our emissions today have committed the planet to climate change well into the 21st century. Delaying control measures will increase this "global warming commitment" still further.[6]

2.2 POLICY CONTEXT FOR CLIMATE CHANGE MITIGATION

The scientific evidence indicates that continuing emissions of greenhouse gases are altering global climate. In response, governments at the international and national levels are taking action to reduce emissions of greenhouse gases. Many individual states have also recognized the potential dangers that global climate change presents to both current and future generations. This section first describes international and national responses to climate change and then discusses the role of states in addressing this global concern.

2.2.1 Introduction to International and National Responses to Climate Change

[6] While this document concentrates on policy formulation to reduce or stabilize greenhouse gas emissions in order to mitigate climate change, other EPA and state research focuses on state-level adaptation to the significant impacts described above should the greenhouse effect intensify.

The international community has coordinated efforts to address the potential impacts of climate change, particularly within the last decade. Some of the more important events are described below.

- *Villach and Bellagio Workshops*: The Villach workshop assessed the role of carbon dioxide and radiatively active constituents under various climate scenarios and assessed the potential impacts under each. The goal of this workshop was to provide a technical basis for a subsequent policy workshop in Bellagio, Italy.

- *The Montreal Protocol on Substances That Deplete the Ozone Layer:* In response to growing international concern about the role of CFCs in destroying stratospheric ozone, 47 nations reached agreement on a set of CFC control measures in September 1987. The control measures, known as the Montreal Protocol on Substances that Deplete the Ozone Layer, laid out a schedule of production and consumption reductions for many CFCs. In June 1990 the Parties to the Protocol agreed to a complete phaseout of CFCs and other ozone-depleting substances (ODSs) (this agreement is known as the London Amendments). In November 1992 Parties accelerated the phaseout schedule for ODSs and agreed to phaseout dates for HCFCs, which are CFC substitutes in many current applications (this agreement is known as the Copenhagen Amendments). As of June 1997, over 160 countries had ratified the agreement.

- *Toronto Conference:* This international conference focused on the implications of climate change for world security and established a goal for industrialized countries to reduce carbon dioxide emissions by 20 percent of 1988 levels by 2005. It was attended by more than 300 policy-makers and scientists from 48 countries.

- *The Intergovernmental Panel on Climate Change:* Under the auspices of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC) was formed in 1988 to conduct studies on global warming. Efforts undertaken include identifying emission sources, assessing possible consequences, and developing mitigation strategies.

- *The International Geosphere/Biosphere Program:* This program was established through the International Council of Scientific Unions in 1988 to facilitate understanding the present state of the earth and the potential impacts of global climate change. This extensive program maps recent global deforestation, produces documents on climate and atmospheric changes, and combines space-based scrutiny of climate change with extensive surveys of land and sea.

- *Noordwijk Conference on Atmospheric Pollution and Climate Change:* The final declaration at this conference encouraged the IPCC to include in its First Assessment Report an analysis of quantitative targets to limit or reduce CO2 emissions, and urged all industrialized countries to investigate the feasibility of achieving such targets, including, for example, a 20 percent reduction of carbon dioxide emissions by the year 2005. The Conference also called for assessing the feasibility of increasing net global forest growth by 12 million hectares per year. During its Third Plenary, the IPCC accepted the mandate.

- *Hague Declaration:* This conference and Declaration (signed by 23 nations) established support for new principles of international law. These principles promote the creation of standards to guarantee protection of the world's atmosphere and combat global warming. The U.S. and Soviet Union were not invited to the conference to avoid potential East-West policy conflict.

- *Cairo Compact:* The compact calls on affluent nations to provide developing countries with the technical and financial assistance to address global climate change.

- *United Nations World Climate Conference:* The IPCC reported the findings of the IPCC Working Groups to the United Nations (Scientific Assessment, Impacts Assessment, and Response). The IPCC report, adopted by the General Assembly, set the stage for future international negotiations on a framework convention on climate change.

- *Intergovernmental Negotiating Committee (INC):* On December 21, 1990, the U.N. General Assembly established the INC to prepare an effective framework convention on climate change, containing appropriate commitments and any related legal instruments as might be agreed upon. The INC, supported by the WMO and UNEP, has convened for ten sessions since its formation. The INC serves as the international mechanism to monitor and enforce the provisions of the United Nations Framework Convention of Climate Change (FCCC). The INC is also currently negotiating to adopt a framework to implement a joint implementation regime.[7]

- *United Nations Conference on Environment and Development (UNCED):* On June 12, 1992, at UNCED (the Earth Summit) in Rio de Janeiro, 154 nations, including the U.S., signed the U.N. Framework Convention on Climate Change. The Convention contains a legal framework that commits the world's governments to voluntary reductions of greenhouse gases, or other actions such as enhancing greenhouse gas sinks, aimed at stabilizing atmospheric concentrations of greenhouse gases at 1990 levels. To facilitate this, Article 4-1 requires that all parties to the FCCC develop, periodically update, and make available to the Conference of the Parties, national inventories of all anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies. In October 1992, the U.S. became the first industrialized nation to ratify the Treaty, which came into force on March 21, 1994. The Convention also contains other binding agreements related to its establishment, support, and administration.[8]

- *Bilateral Sustainable Development Accord Between Costa Rica and the U.S.:* On September 30, 1994, the U.S. and Costa Rica signed a bilateral accord intended to facilitate developing joint implementation projects. These projects are intended to encourage the use of greenhouse gas-reducing technologies (including energy efficiency and renewable energy technologies); develop educational and training programs; diversify energy sources; conserve, restore, and enhance forest carbon sinks (especially in areas that promote biodiversity conservation and ecosystem protection); reduce greenhouse gas emissions and other pollution; and promote the exchange of information regarding sustainable forestry and energy technologies. This accord should provide the basis for future similar arrangements between countries and contribute to establishing an international joint implementation regime that is sensitive to environmental, developmental, social and economic priorities. The accord is intended to encourage partnerships involving the federal government, private sector, non-governmental organizations, and other interested entities.

- *1995 First Conference of the Parties:* The INC was dissolved in February 1995, and the Conference of the Parties (COP) became the new ultimate authority of the FCCC. During the first

[7] The concept of "joint implementation" (JI) was introduced early in the negotiations leading up to the 1992 Earth Summit in Rio, and was formally adopted into the text of the FCCC. The term "JI" has been used subsequently to describe a wide range of possible arrangements between interests in two or more countries, leading to the implementation of cooperative development projects that seek to reduce or sequester greenhouse gas emissions.
[8] To fulfill its obligation under the FCCC Article 4-1, the U.S. government published the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1993* (U.S. EPA, 1994). The U.S. also published the *Climate Action Report* (U.S. Government, 1994), in accordance with Article 4-2 and 12. The *Climate Action Report* provides a description of the U.S. climate change program.

Conference of the Parties in Berlin from March 28 - April 7, 1995 (COP-1), delegates agreed on a mandate to establish appropriate action for the period beyond the year 2000, including stronger commitments from developed countries. They formed an Ad hoc Group on the Berlin Mandate (AGBM) to begin work on this process.

- *Ad hoc Group on the Berlin Mandate*: At its first session in Geneva, held from August 21 - 25, 1995, delegates to AGBM -1 began the process of drafting a protocol on new commitments for the post-2000 period. The AGBM has met 3 times since then, and has begun making specific proposals for new reduction targets and strategies for both industrialized and developing countries.

- *1996 Second Conference of the Parties*: COP-2 met in Geneva from July 8 - 19, 1996 and endorsed the "Geneva Declaration," which calls for legally binding objectives and significant reductions in greenhouse gas emissions. For the first time, the US agreed to support a legally binding agreement to fulfill the Berlin Mandate being developed by AGBM.

- *1997 Third Conference of the Parties*: COP-3 met in Kyoto, Japan in December 1997, where the parties agreed to an historic protocol to reduce global greenhouse gas emissions and set binding targets for developed nations. (For example, the binding emissions target for the U.S. is 7% below 1990 emissions levels.) The Kyoto Protocol seeks to achieve targets on all six major greenhouse gases by 2008-2012; international emissions trading is included as a compliance option. The parties will meet again at Buenos Aires in November 1998, where the U.S. will attempt to secure meaningful participation by developing countries.

In the negotiations that led to the FCCC, the United States "supported an approach to global action that focused on the development of national policies and measures to mitigate and adapt to climate change, recognizing that only concrete actions will enable the world community to effectively address climate change, and that measures and policies must be rooted in specific national circumstances and fashioned from a comprehensive set of options addressing all sectors, sources, and sinks of greenhouse gases" (U.S. DOS, 1992). To fulfill this goal, the United States has undertaken actions to address climate change, including scientific and economic research, policy analysis, and program development. These actions culminated in the release of the *Climate Change Action Plan* (CCAP) by the Clinton Administration in October, 1993 . The CCAP presents the U.S. strategy for reducing greenhouse gas emissions to 1990 levels by the year 2000. Neither the measures initiated in 1993 nor the additional actions developed since then will likely be adequate to meet the emissions goal enunciated by the President, but they have significantly reduced emissions below growth rates that otherwise would have occurred. The analysis used to develop CCAP significantly underestimated the reductions that would be needed to return emissions to 1990 levels by the year 2000. Lower-than-expected fuel prices, strong economic growth, improved information on emissions of some potent greenhouse gases, and diminished levels of funding by Congress are among the factors responsible for the need to revise the CCAP goals. Based on current funding levels, the revised action plan is expected to reduce emissions by 76 million metric tons of carbon equivalent (MMTCE) in the year 2000, or 70 percent of the reduction projected in the CCAP. Annual energy cost savings to businesses and consumers from CCAP actions are anticipated to be $10 billion (1995 dollars) by the year 2000. Even greater reductions are estimated from these measures in the post-2000 period: reductions are projected to be 169 MMTCE in 2010, and 230 MMTCE in 2020. Annual energy savings are projected to grow to $50 billion (1995 dollars) by the year 2010.

Also at the national level, the Department of Energy has released a set of draft guidelines for entities to voluntarily report their reductions of greenhouse gas emissions and fixation of carbon, achieved through any measure. The purpose of these guidelines is (1) to provide a database of information for entities seeking to reduce their own greenhouse gas emissions; (2) to establish a formal record of emissions and emission reductions and carbon sequestration achievements; and (3) to inform the public debate in future discussions on national greenhouse gas policy.

The CCAP and other U.S. actions are the outgrowth of more than $2.7 billion in global change research conducted since 1990 (U.S. DOS, 1992). This research includes a variety of multinational scientific projects. For example, the U.S. Global Change Research Program coordinates research of the EPA, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration, the National Science Foundation, and the Departments of Energy, Agriculture, Interior, and Defense. The objectives of the Research Program are to evaluate and further current research activities in the U.S. that address scientific questions concerning global climate change, to define future research needs, and to establish federal agency roles. The Research Program is also intended to develop national and international partnerships between governmental bodies, the academic science community, and the private research sector to achieve long-term scientific goals. Much of this research has focused on steps to strengthen the ability of economic, social, and ecological systems to adapt to adverse change; concrete measures to mitigate the risk of future climate change through greenhouse gas reduction measures; aggressive research to improve understanding of climate, climate change, and potential responses; and international cooperation to broaden the global effort in each of these areas.

To foster international cooperation, the *Climate Change Action Plan* makes provisions for reducing emissions internationally through the U.S. Initiative on Joint Implementation (U.S. IJI). U.S. IJI is a voluntary pilot program that contributes to the international knowledge base regarding joint implementation, through projects demonstrating a range of approaches for reducing or sequestering greenhouse gas emissions in different geographic regions. U.S. IJI provides public recognition and selected technical assistance to approved projects. These projects contribute to emissions reductions by promoting technology cooperation with and sustainable development in developing countries and countries with economies in transition. As of July 1997, 26 project proposals have been accepted by USIJI.

Many individual states and localities have also initiated independent climate change responses. At the state level, 29 states have developed a state-level GHG inventory, and 20 states have developed or committed to develop a state-level action plan to reduce GHG emissions. More than 20 states and more than 80 cities and counties have joined Rebuild America, a program which emphasizes energy efficiency improvements, thus reducing greenhouse gas emissions. Over 30 state government agencies and more than 120 local governments have joined EPA’s Green Lights program, making a commitment to replace old lighting fixtures and bulbs with energy efficient lighting, thus reducing greenhouse gas emissions. Portland, Oregon proposes to reduce carbon dioxide emissions from the Portland metropolitan area to 20 percent below the 1988 level by the year 2010 (PEO, 1993). The Urban CO_2 Reduction Project, which is a joint effort between cities, highlights both the international collaboration needed to combat global climate change as well as the key role local governments can take in implementing solutions.

In addition to those deliberate efforts to address climate change, many other recent state and local actions have helped to reduce greenhouse gas emissions. These include initiatives in energy efficiency, urban planning, transportation planning, forest management, agricultural management, and other areas. For example, the Iowa State Energy Bureau's Building Energy Management Program promotes cost-effective energy management improvements in state buildings, schools, hospitals non-profit organizations, and local government facilities. The program covers measures designed to reduce energy consumption, including replacing lights and ballasts; replacing boilers and controls; improving heating and ventilation controls; and improving insulation of roofs, walls, and pipes. By reducing the demand for electricity, much of which is generated from fossil fuel combustion, these measures reduce emissions of both greenhouse gases and other air pollutants. The program also provides financial savings to a state that imports 98 percent of its energy and creates jobs (Wells, 1991). In Minnesota, more stringent energy standards have been adopted for the new construction of residential dwellings and government offices. Oregon has increased the weatherization standards in the construction of low income homes. New York has recently established a public-private partnership to encourage and support schools in making their facilities more energy efficient (*Energy Smart Schools*), and Colorado has established the *Colorado Green Program*, which assists builders and honors residents who construct homes that conserve natural resources and increase energy efficiency. As in Iowa, these programs reduce greenhouse gas emissions and other air pollutants (by lowering electricity demand), while simultaneously providing financial savings and promoting energy security.

States are also increasing the use of compressed natural gas (CNG) in state and municipal vehicles, primarily school buses and buses used for public transportation. For example, in Mecklenberg County, North Carolina all school buses have been converted to CNG vehicles, and in Maryland, the Department of Transportation has replaced its fleet of diesel fuel shuttle buses at BWI with 20 new CNG vehicles. Also in Maryland, the governor signed an executive order which formally expressed Maryland State Government's commitment to improve air quality and to comply with the clean fuel provisions of the *Clean Air Act Amendments of 1990* (CAAA of 1990) and the Energy Policy Act of 1992 (EPAct). The order established an interagency "Alternative Fuels Work Group" which is to evaluate and recommend alternative fuels for use in state fleets. These types of programs provide economic and environmental benefits beyond climate change mitigation. Similar activities are highlighted throughout this document.

2.2.2 Importance of State Action

On both a total and per capita basis, many states emit carbon dioxide in amounts comparable to some of the highest emitting countries in the world. Although problems such as global warming need to be addressed through cooperative national and international efforts, many of the critical responses can be initiated locally. If the adverse effects of climate change are to be avoided, states will need to take an active and immediate role in addressing greenhouse gas emissions. The section below presents several of the foremost reasons that states may wish to take definitive action to reduce greenhouse gas emissions.

States retain much of the policy jurisdiction over emission sources.

States have the power to alter greenhouse gas emission patterns significantly through their influence and authority over energy use, land use, transportation, taxation, environmental programs, and other relevant policy areas. Although some states have started to deregulate some aspects of the utility sector, many state governments still hold direct regulatory authority over electric and gas utilities, which are responsible for one third of the current carbon dioxide emissions (US EPA, 1995). In addition, state public utility commissions (PUCs) oversee decisions regarding the need for new generating capacity and the choice of fuel mix. Many PUCs are now requiring utilities to include environmental considerations explicitly in their decision making. The federal government does not have jurisdiction over many of these areas.

States can also encourage local governments to revise or establish building codes and land use regulations. Some local governments have implemented stringent energy efficiency requirements for new housing. For example, two California cities, Davis and Berkeley, require compliance with minimum residential energy standards as a condition for the sale of a home (Randolph, 1988). The state's authority to conduct land use planning can also have a dramatic impact on emissions from the residential, commercial, and transportation sectors. For example, several cities have undertaken large-scale tree-planting programs to improve air quality and lower summer temperatures, thereby reducing summer energy needs for air conditioning.

Other opportunities for state and local action to reduce greenhouse gas emissions include management of landfills and regulation of existing stationary sources of air pollution. For example, state and local programs to increase recycling and source reduction of municipal solid waste management promote industrial energy savings from secondary materials manufacturing, reduce landfill methane emissions, and promote forest carbon sequestration(USEPA 1997b)).

The Climate Change Action Plan creates new opportunities for states.

The *Climate Change Action Plan* offers both opportunities and support to state action in a number of sectors. For example, the federal government has made a commitment to promote integrated resource planning (IRP) by utilities, specifically including technical and financial assistance to states. Similar opportunities are being fostered in the transportation, agriculture, and other sectors. The CCAP also commits federal agencies to further link their programs to state and local initiatives.

States have the capacity for enacting "low risk" policies to address climate change.

States can implement many climate change mitigation measures that have immediate, non-climate related benefits. This opportunity enables states to supplement existing policy goals with climate change policies. For example, in addition to reducing greenhouse gas emissions, investments in energy efficiency will lower energy bills of state residents and reduce emissions of local air pollutants. Promoting energy efficiency not only benefits the consumer, but may also provide for a stronger and more efficient economy. By saving energy costs in the production of goods, energy efficiency can improve the competitive position of states in both national and international markets. Energy efficiency provides increased energy and economic security by lessening dependence on foreign oil and other fuel supplies (Schmandt et al., 1992). Reforestation and urban tree programs not only sequester carbon but can also reduce cooling energy requirements and aesthetically improve the urban and rural environment. Movement away from certain fertilizers in agricultural practices may reduce problems of groundwater contamination from their residues.Composting agricultural crop wastes enhances soil fertility while reducing particulate emissions and smoke. All these actions reduce greenhouse gas emissions.

These types of measures often present little economic or political risk to policy-makers. Many policies provide states with economic benefits regardless of any future changes in climate. For example, the EPA's Green Lights Program encourages the use of energy efficient lighting. Energy efficient measures result in lower energy bills and the overall benefits that society gains from such programs often outweigh the total costs incurred. In addition, in most instances these policies carry little political risk because they complement existing programs. For example, policies on greenhouse gas emission reductions in New York are generally framed in the context of state energy planning. New York's State Energy Plan was developed jointly by the State Energy Office, the Department of Environmental Conservation, and the Public Service Commission. Together, these agencies developed energy policies to achieve environmental, energy, and economic policy objectives. Thus, adopting low risk measures can not only result in multiple benefits, but also enhance economic and political feasibility.

Many other "low risk" programs are already in place. For example:

- *The Connecticut Department of Transportation* has pioneered programs to increase the use of car pools, van pools, and public transportation. By assisting commuters to find alternatives to driving alone, these programs reduce traffic congestion, pollution, and greenhouse gas emissions.

- *The Georgia Governor's Office of Energy Resources* is increasing energy and agricultural efficiency by facilitating six programs targeted to crop, poultry, and livestock producers. These programs conserve energy and save money in addition to reducing greenhouse gas emissions.

- *The Missouri Department of Natural Resources* has created a reforestation program designed to reduce heating and cooling needs with strategic landscaping, to arrest soil erosion, enhance natural water filtration, and remove carbon dioxide from the atmosphere. The program coordinator of this multifaceted project, called Operation TREE, must work to involve every division of the Department of Resources and encourage cooperation among other state agencies (Wells, 1991).

- *The Alabama Broiler Litter Program*, co-sponsored by the Science, Technology and Energy Division of the Alabama Department of Economic and Community Affairs and the USDA's Tennessee Valley Resource Conservation and Development Council, addresses energy conservation, reduces the landfill waste stream, promotes recycling, and improves agricultural productivity. In this program newspaper is shredded and blown over the poultry house floor, where it becomes matted and slick from droppings and moisture content. When the litter and paper is gathered from the floor, it is spread on crops as fertilizer, or is mixed with feed and is fed to livestock. The paper also acts as an insulator for the poultry house, thereby reducing energy needs (*Conservation Update*, September 1993).

- *The Minnesota Department of Public Service, Energy Division* has adopted new standards to achieve higher levels of energy efficiency in new construction. These regulations will not only decrease energy demands of consumers, but will also reduce consumers' overall energy bills while simultaneously reducing CO_2 emissions through decreased electricity demand (*Conservation Update*, July 1994).

- *The Governor of Wisconsin* signed a major energy policy directive that mandates state agencies and local governments to implement the following priorities when making energy decisions: (1) energy efficiency; (2) non-combustible renewable energy resources; (3) combustible renewable energy resources; and (4) non-renewable combustible energy resources (natural gas first, then oil, then coal with low sulfur content, and then other carbon-based fuels) (*Conservation Update*, June 1994).

These measures demonstrate how states have already implemented programs that address climate change, and that action in this area does not place policy-makers on entirely new ground. Further, the existence of such programs highlights coalition building as an important part of addressing climate-related problems, since the responsibility for solving many environmental problems is often widely spread among diverse state agencies (this issue is discussed in greater detail in Chapter 7).

States will feel the impacts of climate change and will likely be called upon to address them.

Although climate is a growing concern, climate-related problems will ultimately affect local and state economic sources. Further, recent surveys indicate that public opinion supports a greater environmental consciousness. A growing number of Americans are becoming "green consumers" and "green voters," *i.e.*, they incorporate environmental considerations into their buying habits and political choices (Cale et al., 1992). Thus, state governments may face public and political pressure to respond to climate change.

Because state governments are often more attuned to local public sentiment than are their federal counterparts, the state planning process can incorporate localized public input and priorities. Federal agencies, however, must craft programs that cover larger regions of the country. As a result, state and regional priorities may be overwhelmed by national interests during federal planning. By initiating their own programs, states can make adjustments according to their own needs, allocate resources as they see appropriate, and complement other state policy goals in ways that the federal government may not consider.

As greenhouse gas emissions continue to emerge as an international and national priority, federal policies and programs will also continue to develop. States that have already started to plan accordingly will experience the least social and economic disruption. By delaying the transition to a more energy efficient economy, for example, a state risks having to make rapid and disruptive adjustments in the future. In addition, by acting now, states will influence future decisions at the national level.

Further, states have the opportunity to assume a leadership role in the global climate change arena. The ten states with the highest carbon dioxide emissions each produce more than the Netherlands, which has taken a key role in promoting international agreements to curb climate change. Denmark would rank 31^{st} among the states with respect to CO_2 emissions (Lashof and Washburn, 1990). Even states with relatively small contributions to climate change can demonstrate to the U.S. and to the world that emission levels can be reduced while economic growth is sustained. As summarized in Exhibit 2-3, a number of states are already arguing for the key role that states can play in this critical area.

State agencies do not shoulder this burden alone. As EPA notes, "no single activity is the dominant source of greenhouse gases; therefore, no single measure can stabilize global climate. Many individual components, each having a modest impact on greenhouse emissions, can have a dramatic impact on the rate of climate change when combined" (Smith and Tirpak, 1989). The state role in solving this global problem can be significant. Although national and international effort is essential for an overall solution, states are uniquely positioned to reduce emissions and, in doing so, to encourage the appropriate national and international responses. The United States and other nations have already recognized the threat that climate change poses and the need for action. States, armed with the same understanding, now face the same decision.

2.3 GENERAL FRAMEWORKS FOR CLIMATE CHANGE POLICY ANALYSIS

Policy formulation can be a complex undertaking that involves understanding the issues at hand, envisioning the range of actions that governments can take to address those issues, and selecting from within this range the approaches that offer the most potential for achieving multiple public goals. The policy formulation process must respond to local circumstances and must fit within institutional, fiscal, political, and other constraints. The presence of uncertainties, diverse economic sectors, and long lag times between emissions and affects, as well as the political sensitivity associated with the climate change issue, further complicates actions to reduce greenhouse gas emissions.

To help clarify this complex issue, this document develops an analytic framework that suggests, first, establishing strong and well-founded focal points for program development and then structuring programs around these focal points. This approach recognizes that states face impediments in effectively reducing greenhouse gas emissions. These impediments take three forms: barriers that inhibit actions to reduce greenhouse gases, perverse incentives that actually encourage greenhouse gas production, and time frame issues that complicate the whole process.

This section addresses each of these three factors. First, it presents the types of barriers that may inhibit effective policy implementation. Next, in order to provide a general orientation and organizing principle for various policy options, it reviews the general structure used to present ideasfor policy solutions in Part II of this document. Finally, this discusses timing issues in climate change policy development.

2.3.1 Barriers to Emission Reductions

Designing climate change mitigation strategies is not a straightforward task. A number of barriers to emission reductions confound the policy design process and may inhibit implementing mitigation programs. These barriers may include technological capacity, information flow constraints, price structures and other market related elements, legal or regulatory issues, organizational or institutional considerations, political considerations, and analytic constraints. These barriers, in particular situations, can either inhibit emission reductions or can actually create incentives that lead directly or indirectly to emissions.

Technological Capacity

Greenhouse gases are produced through the fundamental processes that help our economy and our society function, including food production, commerce, and generation of other goods and services on which we depend in our everyday lives. Improving the technologies critical to these necessary and desirable processes could result in lower greenhouse gas emissions as well as decrease the undesirable activities. Frequently, technologies that can achieve specific greenhouse gas reduction goals are available but not widely disseminated, while in other situations technological improvements or new ways of approaching these fundamental tasks in our society have not yet been developed.

Information Flow Constraints

Information barriers can take three forms. First, in the climate change field, incomplete understanding of the atmospheric science as well as to the probable effects of various policy options on greenhouse gas concentrations impedes developing effective policies. Second, those who emit greenhouse gases, including the general public, may not fully appreciate their role and responsibility. Third, the information that would empower members of society to reduce greenhouse gas emissions is frequently not available or understandable to them. This is often the case when technological improvements to various processes have been developed but are not known to the actors who use those processes in the field.

Price Structures and Related Market Elements

Three distinct factors relating to prices and costs of goods and services can contribute to greenhouse gas production and emissions. First, government subsidies and taxes, which are designed to promote goals unrelated to climate change, can conflict with climate change mitigation policies. Second, prices and costs often do not account for the environmental damage being caused by consumption of the

Exhibit 2-3

State Reasons for Climate Change Response

Motivation (as published in state documents)	State (Source)
. . . it's a powerful concept, to think we can adjust the way we live and could have a powerful effect on our global climate. It's a challenge we should take seriously and should accept.	Louisiana (Hodges-Copple, 1990)
Americans, Iowans included, have become both more informed and more concerned about the environment in the last two years to three years. Public consciousness has absorbed the positive message of Earth Day as well as the horror of environmental disasters.	Iowa (Cale et al., 1992)
Vermont has a strong incentive to lead the way in developing energy policies which properly account for environmental risks. . . . Two problems stand out as demanding special attention: global warming, which threatens all of the planet's people and ecosystems and to which Americans make a disproportionate contribution; and acid deposition, which poses a particular threat to Vermont's environment and way of life.	Vermont (Vermont Dept. of Public Service, 1991)
. . . the limited nature of federal leadership means that California's efforts to reduce greenhouse gas emissions will influence, rather than be directed by, federal leadership. . . . In any event, while unilateral California action to reduce emissions will not solve the problem, California leadership could help facilitate greater cooperation between the States, the federal government, other countries to begin reducing greenhouse gas emissions.	California (California Energy Commission, 1991)
Everyone is familiar with the need to pay insurance today for risks that may occur in the future. Actions to slow global warming are the insurance paid to accommodate the risks from global warming. The insurance proposed in this report would also pay a dividend in a more efficient and resilient economy, cleaner air, and less dependence on foreign oil supplies. Responding to global warming is another reason to manage resources wisely. While this is a global problem, everyone must be part of the solution.	Oregon (Oregon Task Force on Global Warming, 1990)
. . . good environmental stewardship and energy efficiency will make Missouri stronger economically, improve our flexibility in the face of uncertain international markets, and fulfill our environmental responsibilities. These benefits prevail regardless of whether Missouri experiences substantial or subtle climate change. If we fail to be accountable for our role in climate change and ozone depletion, we will pay with diminished quality of life for ourselves and our children. Missouri, as a responsible global citizen, has an important opportunity to create environmental and economic benefits from this challenge.	Missouri (Missouri Commission on Global Climate Change & Ozone Depletion, 1991)
The legislature recognizes that waste carbon dioxide emissions, primarily from transportation and industrial sources, may be a primary component of the global greenhouse gas effect that warms the earth's atmosphere and may result in damage to the agricultural, forest, and wildlife resources of the state.	Minnesota (Minnesota Statutes 116.86)
. . . although Washington's contribution to the greenhouse effect is small, the state can demonstrate to U.S. and world policy-makers that CO_2 emissions can be reduced while sustaining economic growth.	Washington (Lesser et al., 1989)
Because Texas has a lot at stake in preserving and protecting its water and coastal resources, it is incumbent upon state officials to start to develop the most cost-effective strategies now. ... Texas does have a role in solving this problem. Indeed, with so much of the structure in place to correct this problem to which we so heavily contribute, it can be asserted that we have an obligation. The next question is: Do we have the political will?	Texas (Schmandt et al., 1992)

goods or services in question; thus, greenhouse gas emissions are an "externality" not reflected in prices. Third, "transaction costs" for obtaining information about, or converting to, more environmentally friendly processes are often high.

Legal or Regulatory Issues

Legal issues affect greenhouse gas emissions in several ways. First, many of the informational and market distortions presented above originate in previous regulatory or other legal action. In these cases, the law itself inhibits reduction of greenhouse gases or even encourages their production. Sometimes this may be to society's benefit because of higher priorities, while in other cases the law inappropriately or inefficiently pursues its objectives, some of which may be outdated. An example of this type of barrier occurs in the regulations that require flaring of methane at landfills, which may exclude its recovery and sale as a fuel source. Second, the absence of regulations or legislation may itself serve as a barrier, as when the absence of certain consumer protection measures inhibits new environmentally friendly technology or product acceptance. Third, ill-defined or vague property rights governing commercially valuable greenhouse gases, such as methane produced from coal mines, can inhibit recovery efforts and thus increase emissions.

Organizational and Institutional Considerations

Institutional factors also may constrain implementing emission reduction policies. Public agencies responsible for developing, analyzing, implementing, and enforcing policies must maintain the skills, resources, and motivation necessary to do this job; without sufficient institutional support, many programs cannot be implemented. In addition, designing emission reduction programs and formulating policy may require distinct institutional mechanisms for coordinating action between public agencies and with many diverse private sector actors. If these channels do not exist, programs can be difficult to develop and administer.

Political Considerations

Greenhouse gas emission reduction policies can affect many actors across all sectors of society. Competing and conflicting interests across these individuals, groups, and organizations can generate significant political tension. In this context, politics may become either an impediment or an asset to climate change policy formulation. Political viability in the climate change arena, thus, depends on the coordination of affected interests, popular or legislative familiarity with the policy instruments being pursued, the perceived fairness of policy ideas, and consistency with other major political agendas.

Analytic Constraints

Several analytic factors may inhibit climate change policy formulation. These revolve around the difficulty and costs of acting when the magnitude and timing of policy impacts are highly uncertain. Chapter 8 discusses many of the issues that create such uncertainty, such as intertemporal comparisons of costs and benefits and issues of interaction between different emission reduction policies.

2.3.2 Structure of Policy Approaches

Because climate change responses must address the wide variety of barriers and constraints presented above, arranging a similarly varied portfolio of policy approaches can enhance program effectiveness. The specific options available for greenhouse gas reduction programs, which are detailed in Chapters 5 and 6, are grouped into four categories:

- Providing information and education;
- Restructuring legal and institutional barriers;
- Providing (and correcting distorted) financial incentives; and
- Implementing direct regulations.

Each of these policy approaches is elaborated on below.

Providing Information and Education

Information provision generally takes three forms: identifying informational needs, generating new information, and disseminating information. Such efforts are usually intended to change the behavior of some target audience (*e.g.*, consumers, corporations, managers, or school children) in order to reduce emissions. Doing so generally requires that policy-makers understand the target audience's current level of knowledge as well as the links between that knowledge and how the audience behaves. For example, energy consumers may not know the most effective ways to save energy, the time and costs involved, or even the linkage to greenhouse gas emissions. By identifying what consumers do generally understand, policy-makers can take action to fill gaps in understanding and knowledge, with the intent to change consumer behavior.

Information dissemination programs may include public advertising or educational campaigns, the provision of information through technical reports, publicity around voluntary standards, public service announcements, media coverage of government activities, support for research and development, technology or process demonstration projects, and direct technical assistance.

Restructuring Legal and Institutional Barriers

Certain legal and institutional barriers not only constrain but prevent effective implementation of greenhouse gas reduction measures. These can include: laws with alternative purposes, such as economic stimulation or public safety, that inadvertently and unnecessarily inhibit greenhouse gas reductions; existing and long-standing operating procedures in public and private organizations that interfere with how policies are implemented; and a lack of institutional or regulatory support capacity for greenhouse gas reduction policy action.

Policy approaches to addressing these barriers frequently include changing existing laws, formulating new laws, and developing new institutional procedures for administering these activities. For example, resolving legal issues concerning the ownership of coalbed methane resources would establish incentives for investment in methane recovery projects (U.S. EPA, 1993b). Similarly, revising outdated laws governing fat content ratings for milk and beef production to reflect modern consumer preferences could result in methane reductions in the livestock sector, by requiring less food intake and digestion per animal for the same quantity of usable food output.

Providing Financial Incentives

Financial incentives involve stimulating private and public sector transactions in order to induce actions that reduce greenhouse gas emissions. This can include changing how current transactions take place, like subsidizing or taxing certain fuel prices to induce choice of cleaner home-heating or transportation fuels, or it can involve fostering new actions all together, like subsidizing or rewarding research on technology development.

Three main categories of action can provide financial incentives to promote public sector goals: 1) direct government expenditures; 2) taxes, fees, loans, or subsidies that alter the consumption of a good or service by changing its price relative to other items consumers might freely choose; and 3) market structures established by governments that stimulate transactions without further direct government action.

Financial incentives are often chosen as a least-cost mechanism for inducing a certain level of production or consumption.[9] For example, by allocating tradeable pollution permits, the federal government is attempting to achieve a pre-determined level of emissions through market interactions, avoiding the rigidity of direct regulation and achieving emission reduction goals at the least cost to society. Similarly, the gasoline tax serves to decrease carbon emissions by reducing gasoline consumption. The four predominant systems through which governments provide financial incentives are tradable emission rights, emission charges, deposit-refund systems, and basic consumption taxes.

Implementing Direct Regulations

Governments can also promulgate direct regulations to address the barriers to greenhouse gas reductions. This may include any legislation or rule that directly limits the action of private and public sector actors. In the climate change field, regulations may force private firms to incorporate social costs of global warming into their decision making process, although financial incentives or other approaches may be more economically efficient and possibly more effective. Direct regulations generally can take two forms: performance standards and technology controls. Performance standards set a limit on a firm's emissions (*e.g.*, 20 lbs./day of a specific pollutant) and allow a firm to choose how to meet the standards. Technology controls, in contrast, define specific design and operating requirements, often specifying required emission control technologies by name.

2.3.3 Timing Issues in Policy Development

A final consideration when developing options for addressing climate change is the issue of timing. Because of the dynamic and complex nature of climate change processes, policies for addressing immediately controllable emissions in the short-term might be entirely distinct from long- term policies necessary for tackling other types or levels of emissions. Given that scientific understanding and the state of technology are evolving rapidly in this field, policy approaches should maintain flexibility. Flexibility is also necessary to respond to changing economic and political circumstances.

The general policy context surrounding climate change roughly spans three time frames -- the immediate- to near-term, the mid-term, and the long-term future. These are relative time frames that help provide focus for programs and that should not constrain programs in any way. Near-term policy responses can usually be initiated quickly, within one to four years, with direct emission reduction or other important benefits. Ideally, they should be incorporated into larger, comprehensive programs. For

[9] See Chapter 8 for more information on least-cost planning.

example, a technical assistance program to help farmers improve fertilizer application placement, timing, and rate will help reduce N_2O emissions immediately and may be the first step in a mid- to long-term program to reduce emissions from the agricultural sector.

Mid-term policies, typically set within five to twenty year periods, frequently depend on issues such as the development and introduction of new technologies and institutional capacity for administering new programs, and are often constrained by the time frames used in economic and energy forecasts. A ten to twenty year span frequently represents the longest periods with which analysts and policy-makers can anticipate the outcomes of their actions. For example, states may not be able to implement programs to support large scale methane recovery and use immediately because of lack of institutional support, but this constraint may be overcome within a few years of program implementation. These policies should be flexible to react to changes in the scientific, technical, economic, and political arenas.

Finally, long-term policies may take several decades to enact. Modifying land use and transportation systems in major cities, for example, can take twenty to fifty years. It is expected that dramatic changes in technology and lifestyles will occur and will have a substantial effect on the climate change problem within this time frame. Thus, research and development and public education are critical components of long-term policy planning.

The policy implications of these three relative time frames are defined in greater detail in Chapter 7. It is important to note at the outset, however, that specific policies may address only one time frame or they can be integrated across time frames. Current policies, for example, can be designed to maximize emission reductions now using available technologies and set the stage simultaneously for future reductions through research and development, education, institutional strengthening, or other actions. Comprehensive state programs should integrate all three time frames in order to maximize the benefits from climate change response strategies. More specifically, effective policy design should ensure that emission reduction goals set in the near-term allow for scientific, technological, economic, and political changes in the mid-term and set the groundwork and the context for addressing long-range objectives.

Each chapter in this document addresses time frame issues. Chapter 3 considers time frames in the context of measuring and forecasting greenhouse gas emissions. Chapter 4 discusses the process of setting and adhering to short-, mid-, and long-term emission reduction targets and goals. Chapters 5 and 6 describe approaches for greenhouse gas emission reductions within the context of what is currently feasible and what scientists and others anticipate being feasible in the future. Chapter 7 discusses how time frames can be used strategically to build political and institutional support in the present and for the future, and provides examples and potential models of policy formulation across time frames. Chapter 8 explains how time frame issues can be incorporated in the policy evaluation process.

Exhibit 2-4 presents a model of public planning that illustrates many of the points made in this chapter. It describes the Air Quality Management Plan for the South Coast Air Basin, an effort organized by multiple agencies that provides a wide variety of social benefits. This plan establishes long-term program goals and then employs different policy approaches set within three distinct time frames, highlighting land use changes that fall under state and local jurisdictions. The policies described here include information and education projects, institutional restructuring and strengthening, and implementation of financial incentives and direct regulations.

Exhibit 2-4: The South Coast Air Quality Management Plan

In July 1991, the South Coast Air Quality Management District and the Southern California Association of Governments adopted a revised, comprehensive Air Quality Management Plan (AQMP or Plan) designed to achieve national and state ambient air quality standards. The 1991 AQMP continues the aggressive emission control program established by previous plans, but also addresses requirements of the California Clean Air Act (CCAA). In addition, the AQMP has been expanded to address global climate change, stratospheric ozone depletion, and air toxics. The 1991 AQMP sets forth programs which require the cooperation of all levels of government: local, regional, state, and federal. The AQMP can serve as a substantive and organizational model for state and local governments in their emission reduction efforts. The Plan is organized into three tiers, each distinguished by its readiness for implementation:

Tier I

Tier I calls for full implementation of known technological applications and effective management practices within the next five years. This phase of the AQMP is action-oriented. It identifies specific control measures for which control technology currently exists.

Tier II

Unlike Tier I, the second phase of the AQMP will require significant advances in current applications of existing technology and strong regulatory action for successful implementation within the next ten to fifteen years. The proposed Tier II control strategy is composed mostly of extensions or more stringent applications of Tier I control measures.

Tier III

The final tier of the AQMP depends on the development, adoption, and implementation of new technologies within the next twenty years. Achievement of Tier III goals depends on substantial technological advancement and breakthroughs that are expected to occur throughout the next two decades. This requires an aggressive expansion of Tier II research and development efforts.

Since the adoption of the 1991 AQMP, the District has been studying the feasibility of implementing a market-based regulatory program for the Basin. Recommendations and findings from this study were presented as the Regional Clean Air Incentives Market (RECLAIM). An amendment to the 1991 AQMP incorporates the concepts of RECLAIM into the existing Marketable Permits Program control measure originally proposed in 1991. RECLAIM calls for declining mass emission limits on the total emissions from all sources within a facility and requires facilities to meet prescribed annual emission reduction targets. Facilities under RECLAIM will be given a facility-wide permit that will detail all emission sources in their facility. Allowing sources to "bubble" facility emissions to meet annual reduction targets increases compliance flexibility at each facility.

CHAPTER 3
MEASURING AND FORECASTING GREENHOUSE GAS EMISSIONS

A state inventory of greenhouse gas (GHG) emissions and sinks is a useful tool both for establishing a baseline level of GHG emissions, and for identifying options for GHG reductions. In addition to preparing an inventory of current GHG emissions, a state may wish to forecast *future* levels of GHG emissions in the absence of state policies to reduce emissions. Such a forecast could serve as a benchmark against which future emission reductions could be measured. The purpose of this chapter is to discuss the usefulness of calculating current and future greenhouse gas emissions, and the methods for doing so.

3.1 MEASURING CURRENT EMISSIONS

The first step in a state's effort to address climate change is to identify all source categories in the state that emit greenhouse gases, and determine their current emission levels. By developing an inventory of greenhouse gas emissions, states can identify those source categories that contribute the most to global warming. The inventory can also be useful for identifying options for greenhouse gas mitigation policies. To assist states in developing GHG inventories, EPA's State and Local Climate Change Program developed a workbook that describes how to prepare greenhouse gas emissions inventories. The *State Workbook: Methodologies for Estimating Greenhouse Gas Emissions* offers relatively simple approaches to preparing an emissions inventory, as well as more sophisticated approaches that generally require more detailed data and a greater level of effort. Several states have used the *State Workbook* to develop a state-level GHG emissions inventory as the first step in developing policies and strategies to reduce greenhouse gas emissions.[1] Exhibit 3-1 presents the emissions sources included in the *State Workbook,* along with a list of the independent variables that are used in the emissions calculations.[2]

3.2 PROJECTING FUTURE EMISSIONS AND EMISSION REDUCTIONS

This section discusses (1) the concept of baseline (or reference case) GHG emissions, (2) methods for forecasting reference case emissions and policy-induced emission reductions, and (3) the potential for "leakage" of GHG emissions (i.e., GHG emissions increases in one sector that result from GHG reductions in another sector).

A state may project the level of GHG emission reductions it will achieve through state-level policies in one of two ways: (1) relative to a static baseline (i.e., the level of GHG emissions estimated in the state's GHG inventory) or (2) relative to a forecasted level of emissions.

Projecting emission reductions relative to a static baseline has the advantage of simplicity -- once the state GHG inventory is developed, no further work is needed to estimate the static baseline. However, to the extent GHG emissions are likely to grow in the absence of state policy, use of a static baseline will understate future emission levels. Moreover, if static data are used to estimate GHG *reductions* due to state policy, the GHG reductions may be understated as well. For example, if a state plans to implement a carpooling program

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[1] See Chapter 1 for more information on the *State Workbook*.

[2] The results of equations used in the *State Workbook* to calculate emissions from each greenhouse gas source are determined by the values assigned to a set of independent variables. These variables reflect the measurable quantities or intensities of various factors that produce greenhouse gases, such as fossil fuel consumption, area of city landfills, or the amount of fertilizer used in a year.

Exhibit 3-1
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

Source Category*	Required Data
Greenhouse Gases from the Residential Sector	State Residential Energy Consumption for the following fuel types: · Gasoline · LPG · Distillate Fuel Oils · Naphtha · Kerosene · Other Solid Fuels · Petroleum Coke · Asphalt & Road Oils · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Coal (by type)
Greenhouse Gases from the Commercial Sector	State Commercial Energy Consumption for the following fuel types: · Gasoline · LPG · Distillate Fuel Oils · Naphtha · Kerosene · Other Solid Fuels · Petroleum Coke · Asphalt & Road Oils · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Coal (by type)
Greenhouse Gases from the Industrial Sector	State Industrial Energy Consumption for the following fuel types (list may not be inclusive): · Gasoline · Other Liquid Fuels · Other Solid Fuels · Distillate Fuel · Bituminous Coal · Natural Gas · Residual Oil · Sub-Bituminous Coal · LPG · Lignite
Greenhouse Gases from the Electric Utility Sector	State Energy Consumption from the Electric Utility Sector for the following fuel types: · Gasoline · Other Liquid Fuels · Other Solid Fuels · Distillate Fuel · Bituminous Coal · Natural Gas · Residual Oil · Sub-Bituminous Coal · Anthracite · LPG · Lignite
Greenhouse Gases from the Transportation Sector	State Transportation Energy Consumption for the following fuel types: · Gasoline (by type) · LPG · Other Solid Fuels · Jet Fuel (by type) · Distillate Fuel · Other Liquid Fuels · Natural Gas · Residual Oil · Bituminous Coal
Greenhouse Gases from Production Processes (e.g., CO_2 from Cement Production)	· Annual Cement Production · Annual Soda Ash Production · Annual Lime Use · Annual Adipic Acid Production · Annual Soda Ash Consumption · Annual Aluminum Production · Annual Nitric Acid Production · Annual Lime Production · Annual HCFC-22 Production · Annual CO_2 Manufacture
Methane from Oil & Natural Gas Systems	· Amount of Oil Produced · Amount of Oil Transported · Amount of Gas Produced · Amount of Oil Refined · Amount of Oil Stored · Amount of Gas Processed · Amount of Gas Distributed
Methane from Coal Mining	· Annual Coal Production from Surface Mines · Annual Coal Production from Underground Mines · Amount of CH_4 Recovered

Exhibit 3-1 (Continued)
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

Source Category*	Required Data
Methane from Landfills	· Amount of Waste in Place · Fraction of Waste in Place at Small vs. Large Landfills · Average Annual Rainfall · Amount of Landfill Gas that is Flared · Amount of Landfill Gas that is Recovered as an Energy Source
Methane from Domesticated Animals	Populations of: · Dairy Cattle · Horses · Sheep · Buffalo · Beef Cattle · Mules · Goat · Range Cattle · Asses · Swine
Methane from Animal Manure	Populations of: Feedlot Beef Cattle: · Steers · Heifers · Cows/Other Other Beef Cattle: · Calves · Heifers · Steers · Cows · Bulls Dairy Cattle: · Heifers · Cows Swine: · Market · Breeding Poultry: · Layers · Broilers · Ducks · Turkeys Other: · Sheep · Goats · Donkeys · Horses/Mules · Percentage of Animal Manure Handled in Each Manure Management System
Methane from Rice Fields	· Total Area Harvested (Not including Upland or Deepwater Rice Fields) · Length of Growing Season
Nitrous Oxide from Fertilizer Use	· Annual Fertilizer Consumption
Forest Sector Carbon Sequestration	· Forested Area · Species Composition · Forest Ages
Greenhouse Gases from Burning of Agricultural Wastes	· Annual Production of Crops with Residues that are Commonly Burned, *e.g.*: Wheat Barley Corn Oats Lentils Rye Rice Millet Sorghum Sugarcane Pea Beans Soybeans Potatoes FeedbeetSugarbeet Artichoke Peanut
Methane Emissions from Wastewater Treatment	· State Population Data · Pounds of Biochemical Oxygen Demand (BOD) Per Capita · Percentage Wastewater Treated Anaerobically · Amount of CH_4 Recovered

* Note: The source categories presented in this table do not make an exact match with the categories addressed in Chapter 5. The source categories in Chapter 5 are based on the categories listed above, but have been modified somewhat to facilitate presentation of available policy options.

Exhibit 3-1 (Continued)
Independent Variables Used in Emission Calculations in the *State Workbook*:
Data Required to Estimate Current Greenhouse Gas Emissions

that will reach a certain percentage of all commuters, and assumes the same number of commuters in 2010 as in 1990, the GHG reductions due to the program are likely to be underestimated.

An alternative approach is to project emission reductions relative to a forecasted reference case which accounts for projected changes in the state's population, economic activity, and other factors. This approach has the advantage of greater realism and thus greater accuracy. Another advantage is that if a state plans to achieve GHG emission levels equal to some percentage of baseline (e.g., 1990) levels, use of a forecasted reference case would allow the state to project whether its policies will achieve the target level of emissions. For example, suppose a state had 1990 GHG emissions of 20 million metric tons of carbon equivalent (MTCE), and forecasted a 2010 reference case of 23 million MTCE in the absence of state policy to reduce GHGs. If the state wanted to reach a goal of achieving 2010 GHG emissions equal to 1990 levels, the state would need to reduce GHGs by 3 million MTCE per year by 2010, relative to the forecasted reference case.

A hybrid approach would be to forecast future emissions only for those sectors in which the state plans to implement GHG reduction policies. This hybrid approach would enable the state to project with relative accuracy the GHG reductions its policies would achieve, in relation to future emission levels in the absence of policy. However, forecasting emissions for only some sectors would not enable the state to estimate total statewide GHG emissions in the absence of policy; thus the state would not know the total GHG reductions needed to achieve some target level of GHG emissions.

One relatively simple method for forecasting future emissions in the absence of GHG reduction policies is to extrapolate the *State Workbook* inventory methodologies using forecasted data (e.g., forecasts of population and economic activity). Under this approach, a state would predict changes in the independent variables (and perhaps some changes in the coefficients in the emission equations), and then recalculate emissions from each affected source category using the *State Workbook* methodologies. Exhibit 3-2 illustrates how changes in the independent variables can be used to forecast (1) emissions in the absence of policy, and (2) emission reductions relative to a forecasted reference case.

Alternatively, an analyst might need to change the coefficients in the emissions equations, or the structure of the equations themselves, in cases where policy alternatives are expected to alter the level of greenhouse gases emitted per unit of activity. For example, technology improvements may increase the amount of electricity produced per unit of fuel consumed, or may reduce the amount of methane that escapes into the atmosphere per ton of municipal solid waste placed in landfills. Exhibit 3-3 illustrates how changes in coefficients can alter emission forecasts.

Note that uncertainty is a significant concern when forecasting greenhouse gas emissions. To prepare reliable forecasts, states should extend emission forecasts only into the near future. Given the degree of uncertainty already associated with existing methodologies and available data, carrying projections beyond this point can undermine the usefulness of forecasts. The maximum time frame for projecting emissions in most situations is likely to be 15 to 20 years -- the typical time frame for energy use projections. Beyond that, uncertainties in technological changes alone will likely call into question the accuracy of forecasts.

Exhibit 3-2: Forecasting Sectoral GHG Emissions
Before and After a GHG Reduction Policy

Suppose a state had 1990 gasoline consumption of 200 trillion Btu (such data are reported in U.S. DOE, 1993). Using the *State Workbook* methodology, 1990 CO_2 emissions from gasoline consumption would be calculated as follows:

CO_2 Emissions =Consumption x Carbon Content Coefficient x Percent Oxidized x 44/12

CO_2 Emissions =200,000,000 million Btu x 41.8 lbs C/million Btu x 99% x 44/12

CO_2 Emissions =15.2 million tons CO_2

Suppose the state forecasted that, in the absence of policy, CO_2 emissions from gasoline consumption would be 10 percent higher in 2005 than in 1990 (based on a projected increase in the driving age population, an increase in the vehicle miles traveled per driver, and some assumption about average mileage per gallon for all cars in the state). Then, forecasted 2005 CO_2 emissions from gasoline consumption in the absence of policy would be 10 percent higher than in 1990, or 16.7 million tons of CO_2.

Finally, suppose that the state planned a carpooling program that was expected to reduce annual vehicle miles traveled by two percent by 2005. The CO_2 reductions and net CO_2 emissions would be calculated as follows:

CO_2 Reductions in 2005 = 2% x 16.7 million tons CO_2 = 330,000 tons CO_2.
Net CO_2 Emissions in 2005 = 16.7 million tons CO_2 - 330,000 tons CO_2 = 16.4 million tons CO_2.

Forecasting can be complex because there are many factors that can affect future emissions, including population growth, economic growth, technological improvements, and degree of urbanization. Possible means of accounting for these external factors include the following: [3]

- *Expert judgment* relies on the insights of experts to forecast future values of key variables. This approach can be effective in considering difficult-to-quantify factors, as well as important interrelationships that may be accounted for by quantitative forecasting methods.

- *Content analysis* is a technique sometimes used to forecast broad social and technology trends. This technique involves reviewing and analyzing the content of the information carried through various media with respect to emerging social trends.

- *Trending methods* are simple linear or logarithmic projections of historical trends, and are rarely used as stand-alone forecasting methods. A more sophisticated variant of trending uses statistical time-series techniques to extract more precise information about trends from historical data. Trend and time-series analyses may be most applicable to short-term forecasts where the influence of structural factors is not expected to be great.

[3] The following bullets were taken from "Methods for Assessment of Mitigation Options" written for the *IPCC Second Assessment Report* by IPCC Working Group II.

Exhibit 3-3: Example of a Policy that Affects Methodological Assumptions

Suppose a state had 700,000 head of beef cattle in 1990. (Such data are reported in USDA, 1990). Using the *State Workbook* methodology, methane emissions from this source would be calculated as follows:

CH_4 Emissions = Animal Population x Emission Factor

CH_4 Emissions = 700,000 head x 152 lbs. CH_4/head/year

CH_4 Emissions = 53.2 thousand tons CH_4

One strategy for reducing methane emissions from domesticated animals is to change their diet. For example, certain feed additives can increase feed efficiency by approximately 10 percent. This change will have a direct effect on the emissions factor above, regardless of any changes in animal population. The magnitude of this change can be calculated using equations provided in the discussion section of the *State Workbook*. Suppose a state implements a policy to increase feed efficiency, and this policy decreases the emissions factor by three percent, to 147 lbs. CH_4/head/year. The methane emissions may be forecasted by using the new emissions factor in the *State Workbook* methodology (the following example assumes no change in the number of beef cattle):

CH_4 Emissions = Animal Population x Emission Factor

CH_4 Emissions = 700,000 head x 147 lbs. CH_4/head/year

CH_4 Emissions = 51.6 thousand tons CH_4

Policy Impact = 53.2 thousand tons CH_4 - 51.6 thousand tons CH_4

= 1,200 tons CH_4

- *Economic forecasting* methods use multiple regression techniques to relate behavior to a series of explanatory independent variables. The specific quantitative form of an economic model is estimated using historical, and in some cases, cross-sectoral data pertaining to the model's independent variables. Forecasts of economic activity, the demand for transportation or forestry products, and emissions can be understood in terms of underlying economic behavior, and therefore, have wide application in the assessment of alternative mitigation strategies.

- *End-use forecasting* models primarily provide a finer level of detail to forecast emissions from the energy sector by representing energy demand within sectors. These methods forecast demand as a function of the efficiency characteristics of specific types of end-use equipment, the utilization of the equipment, and the number of pieces of the equipment in use. Total demand for a given fuel is estimated by aggregating over end-uses, at which point carbon content coefficients and emission factors for other gases can be applied to determine the future emissions potential of various options.

Finally, when accounting for emission reductions, forecasts should also take into account the possibility of “leakage” of GHG emissions -- that is, the possibility that as a state policy reduces emissions in one sector, emissions may, as a direct result, increase in another sector. For example, if a state program promotes use of biomass ethanol as a fuel, with no controls on the energy required to produce the ethanol, the GHG emission reductions from displacing gasoline with ethanol might be offset by increased GHG emissions from fossil fuels used in growing the biomass and producing the ethanol. Many other examples of potential "leakage" could be identified; the challenge for state GHG planners is to identify areas where potential leakage may be significant, and to adjust their estimates of GHG reductions accordingly.

CHAPTER 4
ESTABLISHING EMISSIONS REDUCTION PROGRAM GOALS AND EVALUATIVE CRITERIA

An appropriate mitigation strategy must combine individual projects and programs into a coordinated approach that meets both mitigation objectives and the broader set of state economic, industrial, agricultural, environmental, and other goals. The first step, thus, in a mitigation assessment is to define the set of objectives a mitigation program and/or strategy should meet and to develop criteria for evaluating the success or failure of alternative mitigation strategies. This chapter examines the process of setting broad program goals and specific policy evaluation criteria and highlights the complexities that surround these issues (see Exhibit 4-1 for definitions of the terms goals and criteria). States can choose to set priorities and develop strategies in different ways. For example, goals could be oriented around specific time frames rather than infinite time horizons, focused on quantitative targets rather than qualitative objectives, or based on technical or scientific recommendations rather than on perceived emission reduction capabilities. Exhibit 4-2 presents the key questions states may wish to pose when defining and prioritizing emission mitigation goals. After defining program goals and establishing evaluation criteria, analysts can then assess the feasibility and viability of implementing alternative greenhouse gas mitigation options, such as those presented in Chapters 5 and 6, in light of other state policy objectives. The material presented in this chapter also provides the basis for the discussion in Chapter 8 on analyzing state mitigation strategies.

Exhibit 4-1: Goals and Criteria

Goals: Program goals explicitly state the broad aims that every climate change action should support. By doing so, they provide a consistent focal point for use across diverse situations and between state agencies and across sectors.

Criteria: Criteria are the standards that policy makers can use to assess alternative policy options. Criteria are fundamentally rooted in two types of state policy goals: (1) those that support the climate change mitigation program; and (2) those that ensure that climate change mitigation policies do not impede or negate other state policy priorities or objectives. In contrast to program goals, criteria are more specifically defined and are frequently more directly measurable.

Exhibit 4-2: Key Questions Related to Goal Setting

- Should an emission reduction goal be relative measured against a prior, current, or future reference year?
- How do mitigation objectives relate to existing energy, agricultural, and development policies?
- What type of processes can be used to reach a decision on specific mitigation objectives?
- How can objectives be prioritized?

4.1 EXAMPLES OF GREENHOUSE GAS REDUCTION GOALS

For guidance in setting explicit goals, states can draw on the experience of and research conducted by multilateral organizations, such as the IPCC, and other country, state, and local governments. For example, emissions reduction targets established by the Framework Convention on Climate Change (as discussed in Chapter 2) encourage nations to reduce missions of greenhouse gases to 1990 levels by the year 2000.[1] Several individual countries and some U.S. states and cities have also established their own near- and long-term greenhouse gas reduction goals. Exhibit 4-3 provides examples of these explicit local, state, national, and international program objectives.

[1] This target is for Annex 1 countries only (*i.e.*, developed countries).

Exhibit 4-3: Examples of Climate Change Program Goals

Local Goals

Portland, Oregon, set a target to reduce carbon dioxide emissions from that metropolitan area to a level 20 percent below 1988 levels by the year 2010. This means a reduction of 42 percent from the 2010 level of emissions currently projected.

State Goals

The Wisconsin State Action Plan established a goal to stabilize GHG emissions to 1990 levels by 2010, in large part by cutting CO_2 emissions by 37 million short tons. The Action Plan identifies cost-saving options for reducing CO_2 emissions by 26.2 million short tons, and options for further CO_2 reductions of 36.9 million short tons for under $15 per ton.

Washington set a goal of emissions stabilization by 2010, to be achieved by cutting 18 million short tons of CO_2. Toward this end, the Washington State Action Plan outlines options that could reduce CO_2 emissions by 19 million short tons for less than $5 per ton, or by 44.3 million short tons for about $100 per ton.

The Illinois State Action Plan would stabilize GHG emissions by 2000, through a cut of 10 million short tons of CO_2. Thirty-seven percent of this goal (3.74 million short tons) can be achieved at no cost. The Action Plan describes options which could reduce CO_2 emissions by 28.9 million short tons for about $60 per ton, or by 92 million short tons for about $110 per ton.

Oregon's Action Plan predicts that the state's strategy will reduce GHG emissions by at least 2 million tons (presumably, 2 million short tons of carbon dioxide equivalent) in 2015, compared to a "business as usual" scenario.

National Goals

In the October, 1993, Climate Change Action Plan, the United States set a target of returning U.S. greenhouse gas emissions to 1990 levels by the year 2000 with cost-effective domestic actions. This includes measures in all sectors of the economy targeted at all significant greenhouse gases.

Sweden passed legislation in 1986 to stabilize its carbon dioxide emissions at 1988 levels.

The German cabinet has established a goal of twenty-five percent carbon dioxide emission reductions from 1986 levels by 2005.

International Goals

The objective of the U.N. Framework Convention on Climate Change (UNFCCC), established at the 1992 U.N. Conference on Environment and Development (UNCED) and ratified in March of 1994, is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system and to do so within a time-frame sufficient to allow ecosystems to adapt naturally to climate change. Signatories to the UNFCCC are currently negotiating binding national climate change goals which may be adopted as early as December 1997 in Kyoto, Japan.

The twelve nation European Union (EU) has agreed, in principle, to stabilize carbon dioxide emissions at 1990 levels. The EU has proposed that developed countries reduce GHG emissions to 7.5 percent below 1990 levels by 2005, and 15 percent below 1990 levels by 2010.

In addition, some national and state level governments have chosen to concentrate on those policy options that promise to reduce greenhouse gas emissions while providing additional non-greenhouse gas-related benefits. For example, measures to increase energy-efficiency in appliances and other technologies not only reduce greenhouse gas emissions, but also increase energy independence and economic competitiveness, and lower emissions of criteria air pollutants. Policy options of this type are referred to as "no-regrets" measures, *i.e*., policies that provide benefits other than those directly related to climate change, such as increased energy security or the creation of jobs. Options that can provide significant additional benefits often encounter less resistance politically and garner more public support than mitigation policies that focus solely on the reduction of greenhouse gas emissions.

Exhibit 4-4: Goal Setting in Oregon

Oregon has been a pioneer in responding to global climate change. The Oregon legislature passed a law requiring the Oregon Department of Energy (ODOE) and other agencies to develop a strategy to reduce greenhouse gas emissions by 20 percent from 1988 levels by the year 2005. ODOE fulfilled this mandate by incorporating a greenhouse gas reduction strategy into its 1991 biennial energy plan, although the strategy did not become a formal state goal. Still, the presence of this strategy in the energy plan helps the state project how it will meet its future energy needs and offers specific policies and actions. In this context, the energy plan calls explicitly for the development of a state action plan to deal with climate change, with a target of stabilizing emissions at 1990 levels. This target was set as a state benchmark through recommendation of a "Progress Board" headed by the Governor. Furthermore, within the context of the energy plan, Oregon's qualitative goal is to achieve reliable, least-cost, and environmentally safe sources of energy. Oregon is able to monitor and update its progress towards achieving these quantitative and qualitative goals through the preparation of energy plans every two years.

4.2 COMPLEXITIES IN EMISSIONS REDUCTION GOAL SETTING

This section addresses the factors that make goal setting an analytically difficult task, such as contending with technological, economic, and political constraints. As a result of these factors, goal setting often becomes an iterative process of gathering technical and economic data, analyzing these data and potential response options in the context of resource constraints, projecting future emissions, and then repeating this process until a realistic program can be developed that meets state objectives. Some state governments have conducted this type of iterative analysis before setting any program goals, in order to determine the most realistic approach. Other analysts, however, have based their goals from the outset on pursuing actions required to meet specific mitigation targets, and then mold their programs to meet competing demands at a later stage. Section 4.2.1 presents four basic variables that, among others, policy-makers may wish to address during the goal setting process. Section 4.2.2 elaborates on the complications that can arise during this process.

4.2.1 Four Variable Aspects of Goal Setting Processes

Policy-makers may find it valuable to consider four primary distinctions in goal setting when formulating the core focal points for their climate change programs. These are discussed below.

Goals oriented around specific time frames versus permanent or perpetual goals

While each state should optimally establish a definitive primary objective for programs, such as no net increase in greenhouse gas emissions or stabilization to some baseline level, more specific goals and program milestones set within distinct time frames can provide critical guidance for policy development and implementation. In the context of a long-term baseline goal, for example, specific near-term reduction targets may provide important motivation to agencies and private sector actors to implement options.

Similarly, certain policy actions are appropriate in the near-term and others in the mid- or long-term. Careful goal structuring that accounts for these time frame differences can significantly strengthen program development. Policies adopted in the near-term may substantially lower the costs and increase the acceptance of future actions by, for example, focusing on the development of technologies that minimize emissions or by demonstrating early the cost-effectiveness of an option.

Quantitative goals versus qualitative goals

Programs may pursue specific numerical targets for emission controls, or they may focus on qualitative issues, such as promoting the use of the most energy-efficient technologies and processes in all economic sectors. Setting quantitative emissions reduction goals, such as Oregon or Missouri's twenty percent target, can be extremely effective in focusing state efforts across sectors. Quantitative goals may also allow analysts to assess more easily the feasibility for alternative policy options to meet specific targets and to monitor with greater accuracy the progress of these options. The Oregon target, for example, seems to provide continuing focus as policies are developed and revised over time. Similarly, the California state directive to evaluate the pros and cons of a CO_2 reduction target, although it has not actually produced a formal quantitative target, has prompted important analysis of how existing and potential new state policies may affect projected greenhouse gas emissions.

Goals based on prescriptive emissions targets versus goals based on perceived emission reduction capabilities

Policy-makers may decide to set goals based on technical or scientific prescription of emission levels necessary for climate change mitigation (*e.g.*, stabilization at 1990 levels), on actual emissions or technological projections (*i.e.*, implement measures that will achieve the maximum amount of emissions reductions possible given the current and projected state of technology), on state administrative and analytical capacity for implementing and supporting certain types of programs (*e.g.*, base emissions reductions targets on the number of climate change projects/programs state agencies can realistically manage over the period being considered), or on a range of other emissions reduction criteria. This choice will often determine how aggressive or conservative program development and policy selection are, and it will also affect the types of demands programs place on state resources.

Broad versus narrow substantive goals

Goals can cover all greenhouse gas emissions or they can emphasize specific greenhouse gases or particular economic sectors. This again will hinge on each state's motivations and institutional structures and will probably vary significantly with greenhouse gas emissions characteristics in different geographic regions. Many domestic and international efforts focus explicitly on carbon dioxide or on fossil fuel consumption in transportation and electricity generation, for example, since these source categories account for the majority of anthropogenic greenhouse gas emissions. Similarly, some areas choose to focus on stationary source emissions rather than mobile source emissions, since stationary sources are often easier to monitor.

4.2.2 Complications that Affect Goal Setting

Distinct economic, environmental, and political circumstances in each state will probably determine the relative importance of the above four issues for the policy formulation process. This section elaborates on specific issues that complicate the analysis of the four aspects of goal setting discussed above including: the scientific uncertainty associated with greenhouse gas emissions estimation and climate change-related impacts; the actual impact of mitigation measures on emissions and on climate change; and questions of measurability. Chapter 7 examines how states might structure programs to take full account of these issues in all aspects of program design. Exhibits 4-4, 4-5, 4-6, and 4-7 present examples of how states have dealt with these complications in setting emissions reductions goals and targets.

Scientific and Technical Uncertainties

Achieving permanent stabilization could require carbon dioxide emission reductions of fifty to eighty percent from currently projected levels, as well as significant reductions in the other greenhouse gases. This stabilization goal would be extremely difficult to achieve at the present time, and few analysts seem sure about what levels of emissions reductions are actually feasible. Scientific uncertainties underlie many aspects of our understanding of climate change processes, such as the uptake of CO_2 by forests and the oceans. Further, uncertainties exist in estimating emissions from various source categories and in assessing the potential greenhouse gas and associated impacts of specific control technologies. Given these uncertainties, the idea of an optimal emission reduction target is subject to considerable controversy and often becomes defined by other criteria.

Uncertain Impacts and Interactions of Policy Approaches

Some policies may be effective in the short-term, while others will take longer to produce desired results. Also, some options have benefits other than those related to greenhouse gases, such as increased energy security or decreased soil erosion. At the same time, however, these options may prove to be politically unpopular and thus perhaps not feasible, as a result of potentially significant sectoral economic impacts or required changes in behavior. As one illustration of these issues, policy measures such as taxes and other economic incentives can be the most effective in modifying consumer behavior, but they also frequently generate the highest levels of political resistance.

Exhibit 4-5: Goal Setting in Missouri

Missouri's 85th General Assembly adopted a resolution in 1989 that created the Missouri Commission on Global Climate Change and Ozone Depletion. The commission consisted of 14 members with various backgrounds and was charged with assessing Missouri's contribution to these global environmental and social problems, and to offer possible policy alternatives. The Commission's report was presented to the Missouri General Assembly, in 1990. This report was well received and has served as a catalyst for discussion throughout the state. As a result of the Commission's recommendation, Missouri's Environmental Improvement and Energy Resources Authority and the Division of Energy of the Department of Natural Resources have initiated a comprehensive state energy study. Furthermore, the Commission's charge was extended in order to study and fully develop options for preparation and mitigation of effects associated with global climate change and ozone depletion. In addition, Missouri established a non-binding goal of reducing greenhouse gas emissions by twenty percent. This goal has apparently provided a valuable focal point and source of motivation for the state legislature, state agencies and other organizations.

Exhibit 4-6: Goal Setting in Vermont

In October 1989, Vermont's governor signed an executive order calling for a comprehensive review of all forms of energy used in the state and for the development of a plan to modify energy usage in order to achieve specific goals relating to environment quality, affordability, and renewability. Goals include a reduction in per-capita non-renewable energy use of twenty percent and a reduction in emissions of greenhouse gases and acid rain precursors by fifteen percent, both by the year 2000. To meet this charge, the Vermont Comprehensive Energy Plan was developed cooperatively by the Vermont Department of Public Service, the Agency of Natural Resources, the Agency of Transportation, and many of Vermont's leading authorities on energy usage. The Plan showed that through actions to modify and adapt the state's energy usage to meet the goals laid out in the executive order, Vermont can reduce greenhouse gases by twelve percent, acid rain precursors by eighteen percent, and the per-capita use of non-renewable energy by twenty-seven percent.

Similarly, broader and more qualitative goals may be effective in addressing these issues, but complications surround them as well. For example, Massachusetts' explicit goal of providing electricity at the lowest possible financial, social, and environmental cost accounts for the social effects of carbon dioxide from energy production in addition to addressing the environmental impacts of energy production. The energy goal thus incorporates a variety of social objectives and may serve as a model for addressing the impacts of greenhouse gas emissions from many sources, including utilities, industries, commercial and residential buildings, and transportation. This approach may be especially valuable in situations where different sectors could be unevenly affected by emission reduction policies if clear groundwork is not laid in advance. However, this broad, qualitative goal may complicate the projections of emission reductions resulting from the policies, and create political controversy over methods and procedures adopted for quantifying benefits.

Measuring Results

The direct effects of important climate change-related policy actions are often extremely difficult to measure or forecast. For example, quantitative goals, while often politically and analytically difficult to set and agree upon, are frequently much easier to assess and communicate than qualitative goals. On the other hand, many qualitative and inherently difficult-to-measure actions, like broad public education on climate change and energy-efficiency issues, may offer some very good opportunities for achieving long-term climate stabilization.

Similarly, the emission impacts of short-term actions are frequently easier to measure than those of longer-term policies, largely because the longer-term actions (especially those with twenty year or longer time horizons) are subject to complications and interactions from many unforeseeable economic, physical, and environmental developments. To address this issue, states can set detailed near-term targets within the context of broader mid- or long-term qualitative or quantitative goals. This structure, elaborated in Chapter 7, provides a way of focusing measurable or monitorable policy formulation in the short-term and fostering momentum for future program development. It also provides a mechanism to ensure that emphasis on the most promising short term policies does not override or exclude consideration of critically important long-term actions.

Exhibit 4-7: Goal Setting in Iowa

The Iowa Department of Natural Resources delivered the state's first Energy Plan to the General Assembly in 1990. The plan "pointed out the way to a future of wise energy use, economic stability, and environmental quality." With the plan, updated in 1992, Iowa aims to achieve two long term qualitative goals: 1) to meet all new energy demand with efficiency rather than new supplies of fossil fuels, and 2) to effectively double, then double again the share of renewable, "homegrown" resources in the state's energy mix. The plan also sets the objective of continuing to explore how to meet these goals. Towards this end, the state has taken and continues to take steps to create innovative utility energy efficiency efforts, to encourage efficient homes through building ratings, to stimulate alternative energy industries, and to promote research and development through university centers.

The DNR is currently conducting a study that looks at the direct, indirect, and induced effects of increased investment in energy efficiency and renewables. The study is focussed more on the economic rather than environmental analysis of options, since utilities and consumers typically focus on the cost-effectiveness of options rather than the direct environmental benefits.

4.3 ESTABLISHING CRITERIA FOR EVALUATING POLICIES

Clear and consistent policy evaluation criteria can provide a strong base for ensuring that all policies support fundamental program goals. The criteria should not only recognize that some goals may be competing, but should also account for substantive, administrative, and political factors. As opposed to creating strict guidelines to which all policies must adhere, carefully developed criteria establish a framework with which to compare the implications of different policy options. Compiling these criteria carefully at the outset will help ensure that important issues are not overlooked at any time during program and policy development.

Each of the criteria delineated below represents factors that are potentially important to state policy-makers and that, if adopted by an individual state, could be applied to every policy consideration. These should not necessarily serve as constraints that must be met, but rather as guidelines to ensure comprehensive and consistent consideration of all relevant factors during policy selection. At the same time, to evaluate and compare policies effectively, states will probably prioritize among the criteria they adopt. The criteria presented here are drawn from various state experiences and may not be appropriate for all new programs. Each state should develop a set of clear and distinct criteria that reflects their individual priorities and circumstances.

As with the development of quantitative or qualitative program goals, application of specific policy evaluation criteria may vary across time frames. In the immediate-term, for example, existing institutional structures and politics may dominate policy selection. For the mid- or long term, however, policy flexibility and overall economic efficiency may be more important for some states. Some criteria will certainly apply in all time periods. Urban tree planting programs, for example, illustrate these points. While the carbon sequestration value of urban tree planting may be small, this project focuses public attention on the global climate change issue in the near-term, potentially builds political support, and helps alleviate the "urban heat island" phenomenon in the long term. Similarly, some far-reaching and potentially expensive policies may not seem justified if their benefits within the near-, mid-, and long-terms are not all acknowledged. This is especially relevant with regards to climate change, where the impacts and direct mitigation benefits of some actions will probably not be felt for decades.

- *Effectiveness in Reducing Greenhouse Gas Emissions.* This is a key criterion for climate change mitigation policies. Every policy should help reduce current or future greenhouse gas emissions. However, several issues could confound a policy-makers' perceptions of the effectiveness of alternative policy options. These issues include the timing of a policy's effects, the certainty of results from different types of government actions, the degree of control that the public sector seeks to retain, the continuing effectiveness of a policy in the face of economic fluctuations and growth, the responsiveness to technological change, and the degree and impact of interaction among various concurrent policies.

- *Private Sector Costs and Savings*. Most policies will alter the costs recognized by the private sector, including industry and consumers. Policies regulating technology use, industry reporting, or emissions taxes, for example, will impose costs on the private sector and ultimately on the consumers of affected products. At the same time, these or other measures may promote cost savings through energy-efficiency and similar mechanisms. The timing, distribution between affected actors, and magnitudes of costs may all be important to consider.

- *Public Sector Costs*. New policies frequently require implementation, administration, and enforcement support from state agencies. This support costs the agencies, and thus the state government, additional resources in terms of direct financial expenditures, staffing, equipment, and building space. These costs are especially relevant in terms of administering and coordinating programs and maintaining adequate records. For example, all policies will probably require some level of staffing for general administration, and certain non-voluntary emission reduction goals and directives may require additional administrative and field resources for ensuring compliance.

- *Institutional Capacity*. In addition to general public sector resource expenditures for program administration, as noted above, certain types of policies may require distinct institutional capabilities, like the ability to perform specific types of scientific or economic analysis. Similarly, policies may require substantial levels of interagency or public- and private-sector cooperation. An important criterion may be whether states have the existing or foreseeable capacity to meet these types of policy implementation requirements.

- *Enforceability*. In addition to imposing direct enforcement costs, some policies may require new legal powers for state agencies to administer, while some policies may simply be difficult to enforce. This is especially relevant given complications in measuring some greenhouse gas emissions and in measuring the effectiveness of certain policy options. Similarly, regulatory approaches that target large numbers of decentralized emission sources, such as individual consumers who use polluting products or services, may pose especially difficult enforcement problems. For these reasons, the general enforceability of policy options may be an important criterion.

- *Economic Efficiency*. Although many policies can reduce greenhouse gas emissions, policy-makers may want to emphasize options that use resources most efficiently -- *i.e*., achieve emissions reductions using the least amount of private and public resources. Policies that focus first on sources that can provide the lowest cost reductions usually promote these objectives. From a national perspective, cooperation between states and regions may promote least-cost emission reductions.

- *Social Equity*. Both costs and other impacts may be distributed unevenly across certain geographic locations, income groups, or economic sectors. Policies that affect prices of basic consumer goods, such as home heating costs, may have a disproportionate impact on low income individuals. Similarly, some policies may adversely affect one economic sector more than others. For example, policies targeted at nitrous oxide emissions may affect agriculture more than they will affect manufacturing. Additionally, since the impacts and costs relating to climate change extend far into the future, policy-makers may need to grapple with intertemporal inequity between generations.

- *Political Impact and Feasibility*. Public or political acceptability is an essential element of a successful emission control program. Some recommended measures, such as taxes and other economic incentives, for increasing economic efficiency or changing consumer and producer behavior, can generate significant popular resistance. Near- term policies or actions that include public education or that encourage public input and involvement in the climate change decision making process may help build public support.

- *Legal Constraints*. The introduction of some emission reduction policies and goals may be constrained by existing legal barriers. For example, setting land aside for tree planting, requiring utilities to undertake least-cost planning, or addressing environmental "externalities" may all require new or revised laws. Some additional technical approaches for emissions reduction, such as methane recovery from landfills and coal mines, have not been actively pursued before, in part because of legal complications arising from public safety or other concerns.[2] Frequently, these legal constraints can be

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[2] As part of the CCAP, methane recovery from landfills and coal mining is being aggressively pursued. These programs focus on recovering methane for use as an energy source. These programs, the *Landfill Methane Outreach Program* and the *Coal Bed Methane Outreach Program*, are federally-sponsored voluntary programs committed to working with state regulators and industry representatives to maintain public safety, revise current state and local regulations and industry standards, and promote a cost-effective alternative to flaring.

overcome by modifying or broadening regulatory guidelines to permit new activities that still promote initial regulatory objectives, such as public safety, without excluding certain approaches to reducing greenhouse gas emissions. For example, changing landfill methane emission laws to permit recovery and sale of methane, as being pursued in the CCAP, rather than requiring methane flaring as the only safe control measure, illustrates this point.

- *Ancillary Benefits and Costs*. Some climate change mitigation actions could affect other state programs and priorities, either by design or unintentionally. Various potential emission reduction policies produce ancillary benefits by enhancing environmental quality, promoting the sustainable use of resources, enhancing social welfare, enhancing food security, or generating revenue for the government. For example, increasing the use of renewable fuels generated within a particular state could reduce emissions of pollutants from fossil fuel combustion, increase energy independence, lower the balance of trade, and contribute to a state's economic well being. Alternatively, ancillary costs can occur when any policy indirectly works against the factors described above. For example, tree planting programs that sequester carbon, halt erosion, and improve air and water quality may also require large tracts of land to implement, potentially increasing land prices in agricultural areas and thereby increasing prices for agricultural commodities.

In addition to the substantive criteria listed above, state policy-makers experienced with climate change programs have recommended two additional process-oriented criteria that may help provide focus for evaluating policy options.

- *Measurability*. Policy-makers in the climate change field repeatedly emphasize the benefits of being able to measure policy effects. These benefits include accurate emissions forecasting, a sound basis for policy comparison now and for future program analysis and modification, and increased political legitimization of certain options based on their measurable impacts. In addition to the complications surrounding measurability described above, however, some powerful long term and qualitative policies are inherently difficult to assess. For example, it is difficult to quantify the impacts of public and consumer education and of long range land use and urban planning changes. States should be careful not to eliminate these policies from consideration because they are difficult to measure, but rather should anticipate that such policies have different implications for analytic, administrative, and political processes during program planning.

- *Flexibility*. Programs and policies will need to change and adapt over time as more is learned about actual climate change impacts and about the effectiveness of various options for mitigating those impacts. Similarly, flexible state programs may channel their internal and external resources to the most effective applications. This underscores the importance of considering the appropriate time frame in initial program development and is also one of the primary reasons why states may benefit from initiating climate change mitigation programs on their own terms now rather than waiting for less flexible national or international standards. This may have direct implications for policy choice.